

Figure 1. GAC Adsorption Isotherm for Trichloroethylene (TCE)

Matthew L. McCullough

Method for Achieving Ultra-Low Emission Limits in VOC/HAP/TAC Control

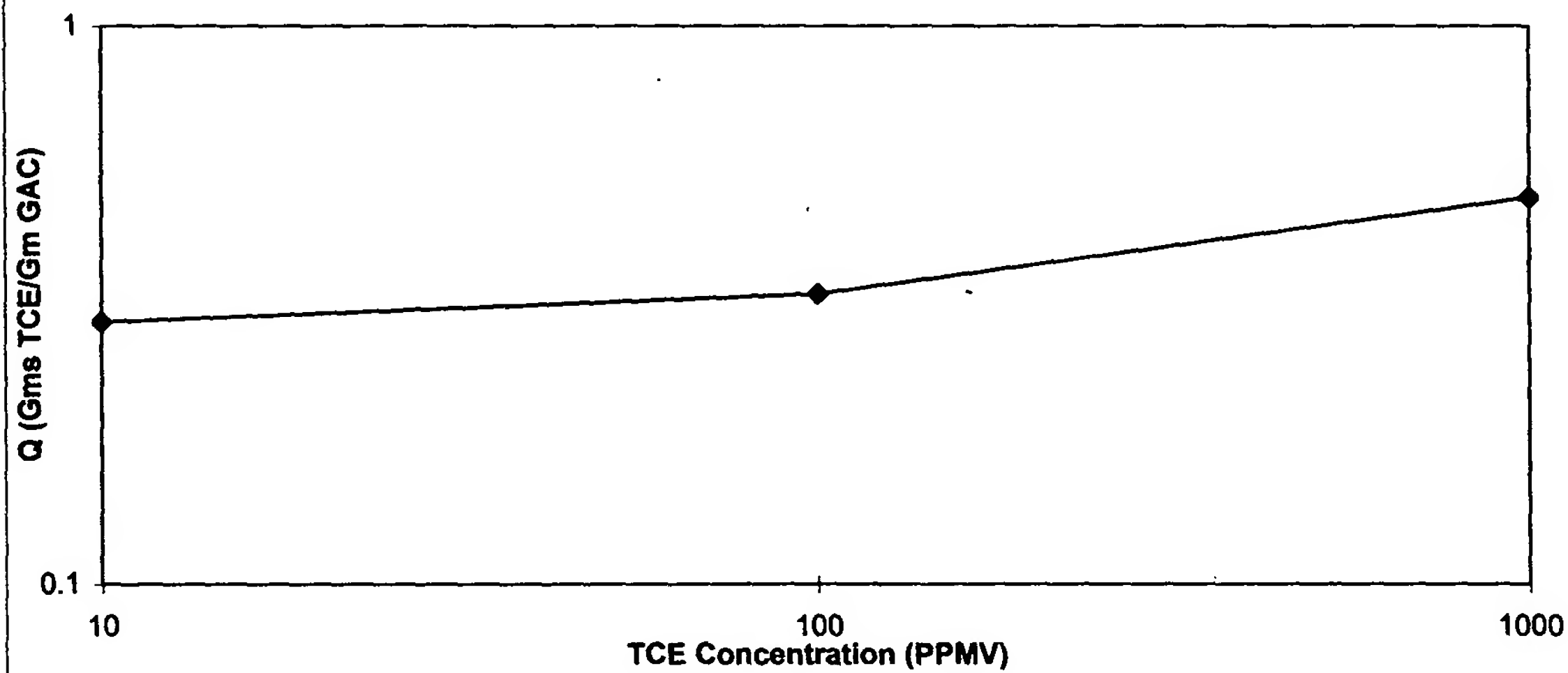


Figure 2. Mass Transfer Zone

Inventor: Matthew L. McCullough

**Title: Method for Achieving Ultra-Low Emission
Limits for VOC/HAP/TAC Control**

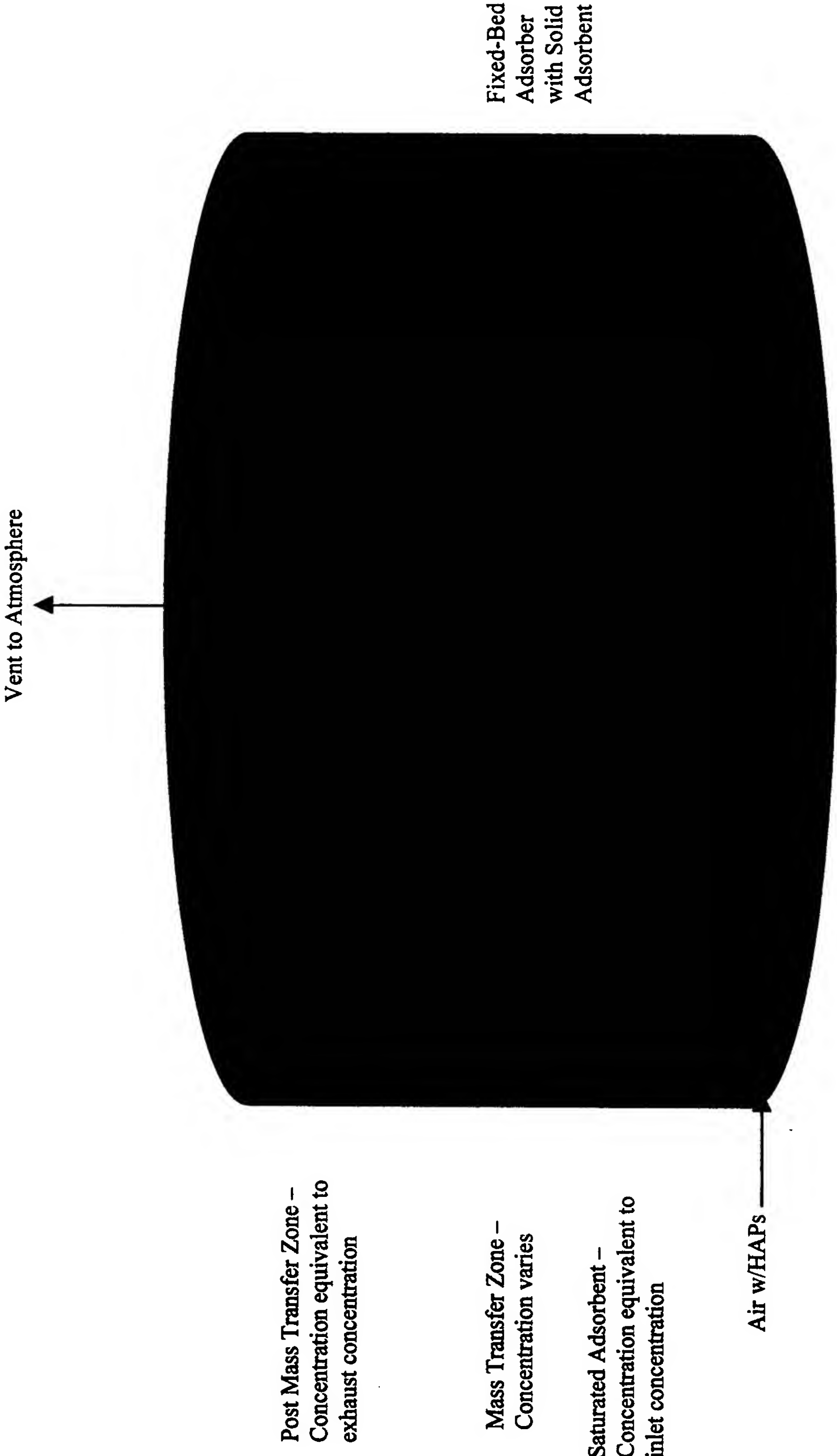


Figure 3. Adsorption Breakthrough Results - GAC Adsorption Bed at Ultra-Low Concentrations Operating in Humid Air Stream

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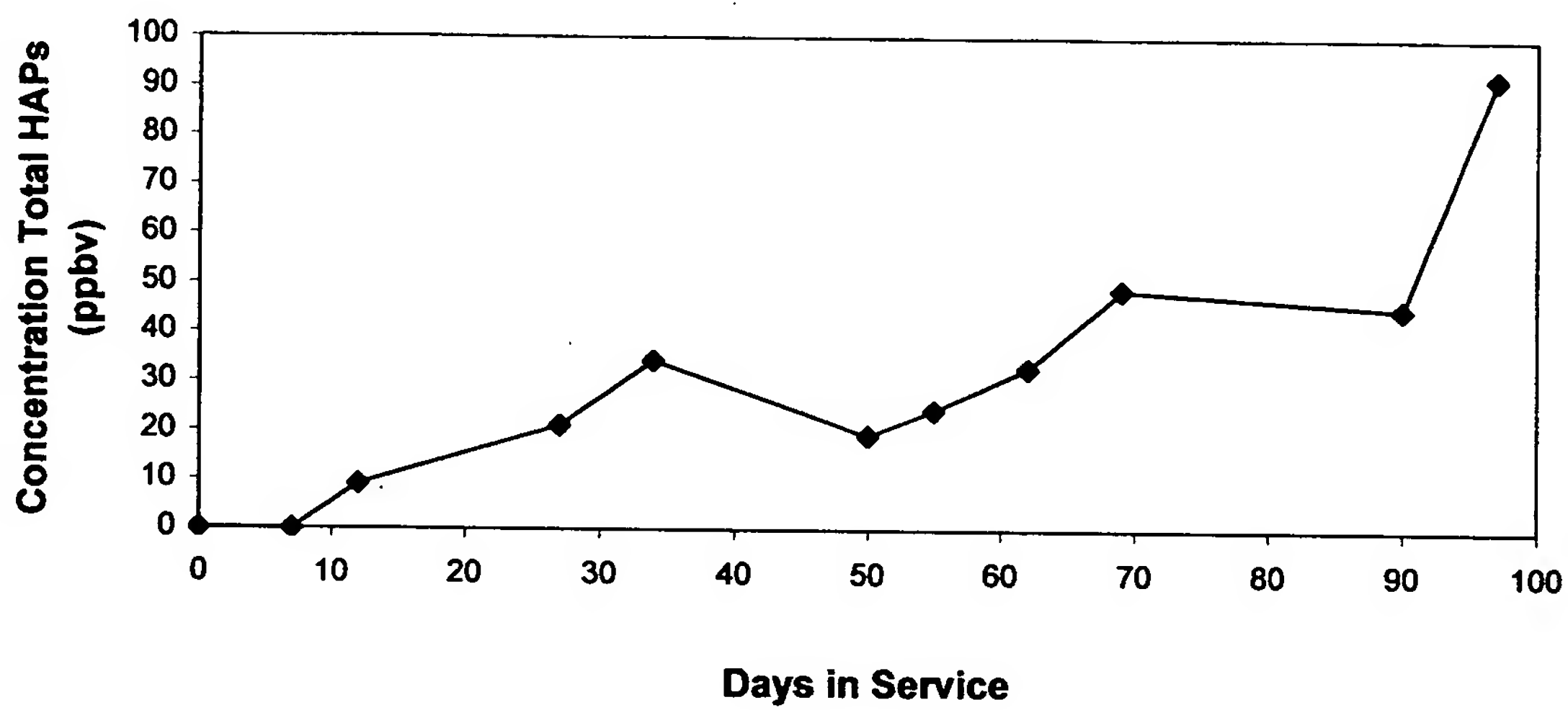


Figure 4: Moisture Uptake for Various Adsorbents

Invntor: Matthew L. McCullough

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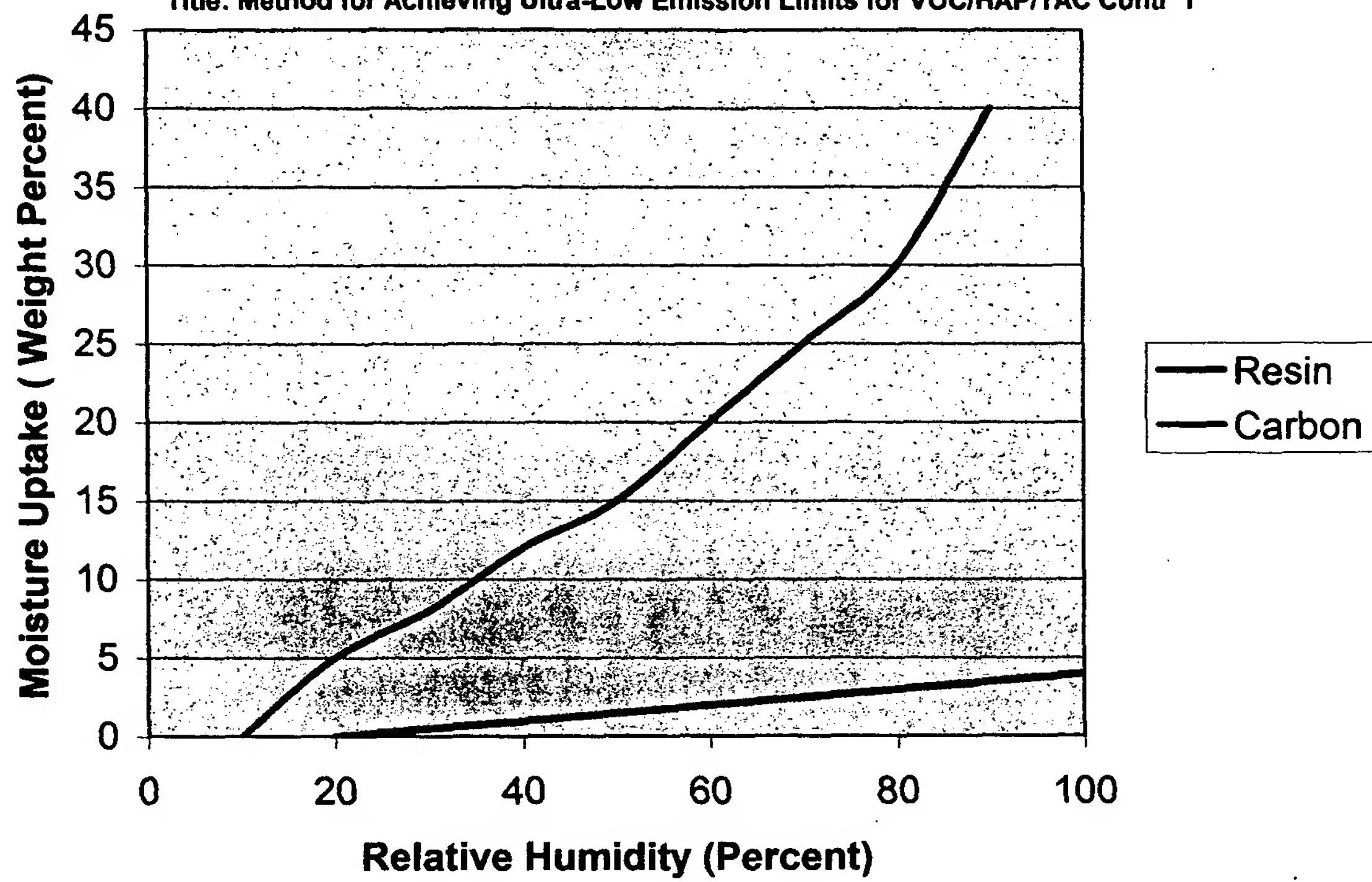


Figure 5. Laboratory Adsorption Apparatus

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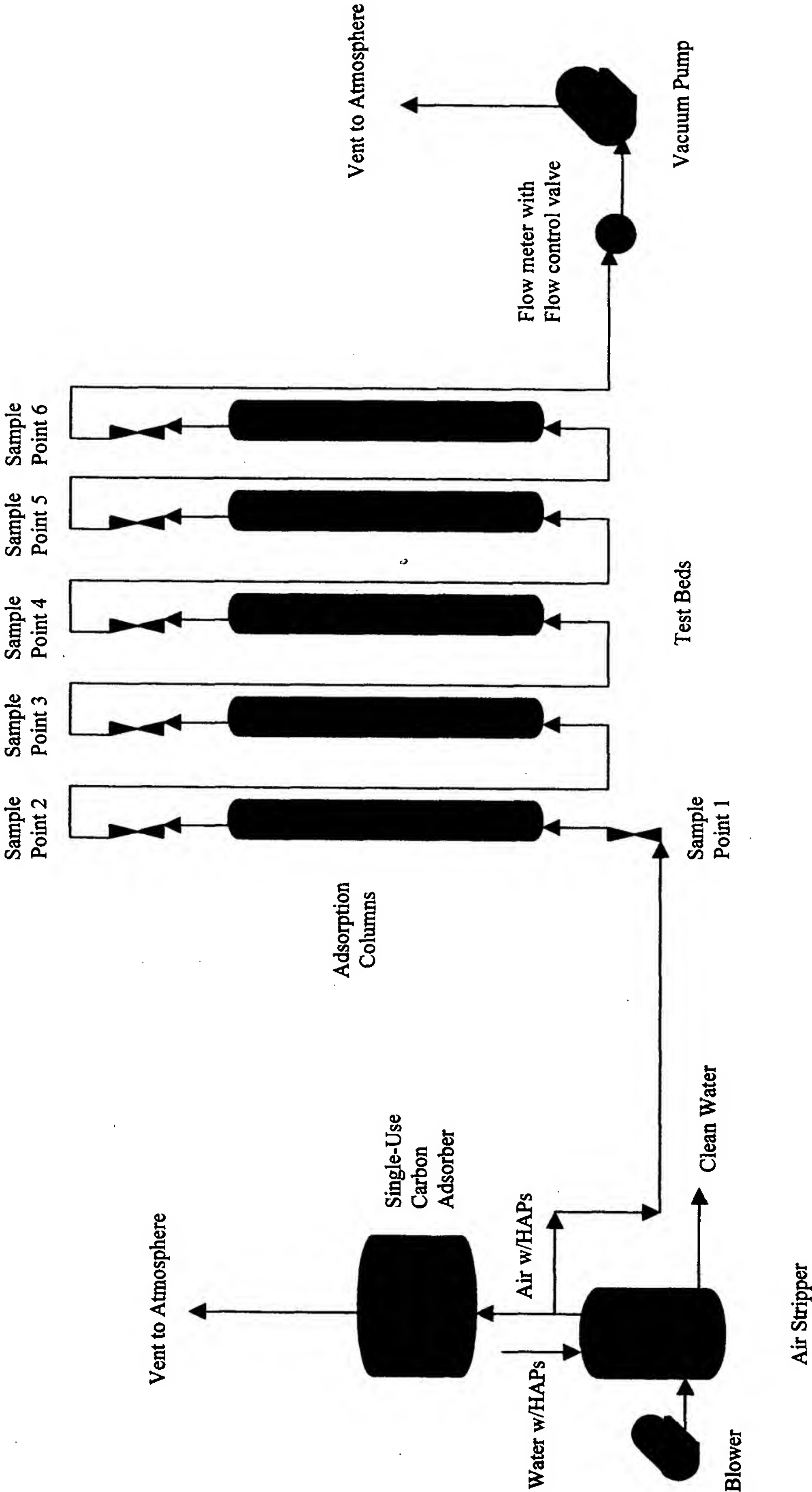


Figure 6. Laboratory Desorption Apparatus

Inventor: Matthew L. McCullough

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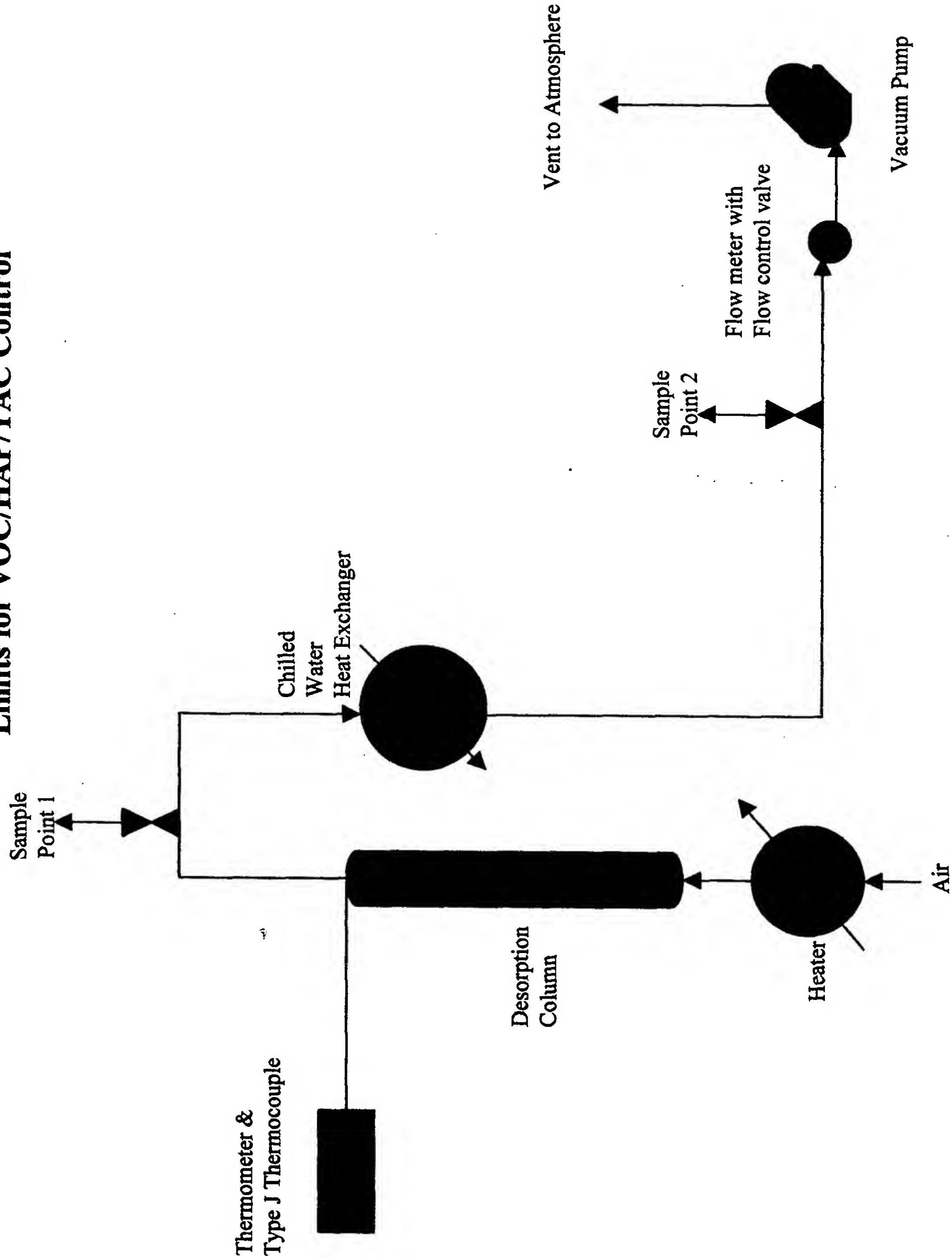


Figure 7. TCE Adsorption Isotherm for Dow x Optipore V503

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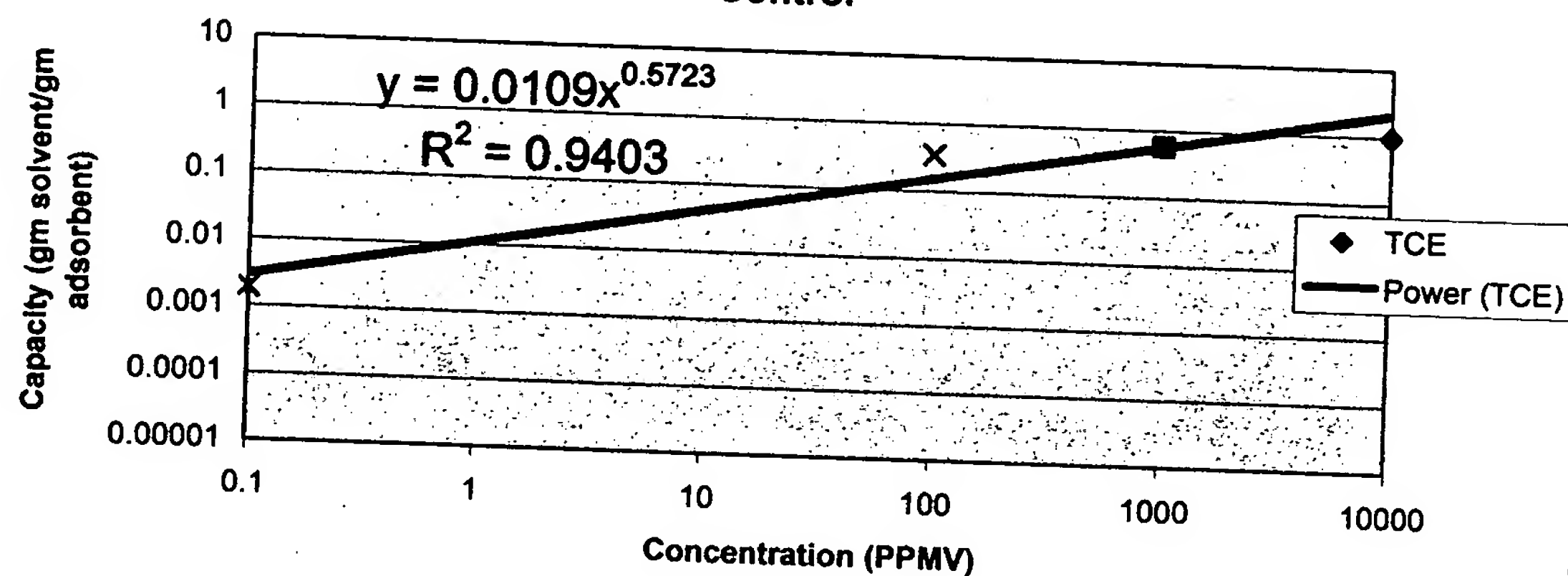


Figure 8. Ultra-Low Concentration Study Results**Matthew L. McCullough****Method for Achieving Ultra-Low Emission Limits for VOC/HAP/TAC Control**

Sample Name	Comment	Result (ppbv)
RAW V493-1D	First sample of raw V493 resin in a fixed-head space 100 ml vial.	Various alcohols and esters.
RAW V493-2D	Second (confirming) sample of raw V493 resin in a fixed-head space 100 ml vial.	Various alcohols and esters identical to first sample.
CLEAN V493-1D	First sample of clean V493 resin not exposed to VOCs in a fixed-head space 100 ml vial.	ND for all compounds – flat chromatogram.
CLEAN V493-2D	Confirming sample of clean V493 resin not exposed to VOCs in a fixed-head space 100 ml vial.	ND for all compounds – flat chromatogram.
DIRTY V493-1D	First sample of V493 resin exposed to VOCs in a fixed-head space 100 ml vial.	~22,000 ppbv TCE 800 ppbv c-1,2-DCE 700 ppbv PCE 270 1,1-DCE
DIRTY V493-2D	Second (confirming) sample of XUR resin exposed to VOCs in a fixed-head space 100 ml vial.	~15,900 ppbv TCE 260 ppbv c-1,2-DCE 240 ppbv PCE
DESORB V493-0.0 MIN	Desorption of V493 resin at design temperature and air flow – initial sample.	7,400 ppbv TCE 100 ppbv c-1,2-DCE 65 ppbv PCE
DESORB V493-1.0 MIN	Desorption of V493 resin at design temperature and air flow – sample after 1 minute.	4,000 ppbv TCE
DESORB V493-3.0 MIN	Desorption of V493 resin at design temperature and air flow – sample after 3 minutes.	1,200 ppbv TCE
DESORB V493-5.0 MIN	Desorption of V493 resin at design temperature and air flow – sample after 5 minutes.	430 ppbv TCE
DESORB V493-22 MIN	Desorption of V493 resin at design temperature and air flow – sample after 22 minutes.	56 ppbv TCE
DESORB V493-45 MIN	Desorption of V493 resin at design temperature and air flow – sample after 45 minutes.	ND for all compounds.
DESORB V493-60 MIN	Desorption of V493 resin at design temperature and air flow – sample after 60 minutes.	ND for all compounds.
DESORB V493-60MIN (FHS)	Fixed head space of sample of desorbed V493 resin at design temperature after 60 minutes of desorption.	ND for all compounds – flat chromatogram.
DESORB V493-100 MIN (FHS)	Fixed head space of sample of desorbed V493 resin at design temperature after 100 minutes of desorption.	ND for all compounds – flat chromatogram.

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Sample Name	Comment	Result (ppbv)
DIRTY V493-1D (SECOND CYCLE)	First sample of V493 resin after 2 desorption cycles and one adsorption cycle in a fixed-head space 100 ml vial.	11,200 ppbv TCE 230 ppbv c-1,2-DCE 220 ppbv PCE
AIR STRIPPER EXHAUST	Test bed influent.	145 ppbv TCE
AIR STRIPPER EXHAUST	Test bed influent – confirming sample.	130 ppbv TCE
C22 REGEN EFFLUENT MIX 1 Desorption Time = 20 Minutes	Effluent from 22 nd regeneration cycle – confirmation of clean resin.	ND for all compounds – flat chromatogram.
C22 REGEN EFFLUENT MIX 2 Desorption Time = 30 Minutes	Effluent from 22 nd regeneration cycle – confirmation of clean resin.	ND for all compounds – flat chromatogram.
C22 REGEN EFFLUENT MIX 3 Desorption Time = 45 Minutes	Effluent from 22 nd regeneration cycle – confirmation of clean resin.	ND for all compounds – flat chromatogram.
C23 REGEN HEADSPACE Desorption Time = 45 Minutes	Fixed-headspace of 22 nd regeneration cycle resin. This provides a worst-case analysis of whether the resin has been completely cleaned.	10 ppbv c-1,2-DCE. Resin has a slight residual of VOCs.
C23 BED 2 @ 25 MINUTES	Adsorption bed 2 (in series) effluent after 25 minutes of operation	ND for all compounds – flat chromatogram.
C23 BED 1 12:30 Adsorption time = 30 Minutes	Adsorption bed 1 effluent after 0.5 hours of operation	ND for all compounds – flat chromatogram.
C23 BED 1 12:45 Adsorption time = 45 Minutes	Adsorption bed 1 effluent after 0.75 hours of operation	ND for all compounds – flat chromatogram.
C23 BED 1 13:30 Adsorption time = 90 Minutes	Adsorption bed 1 effluent after 1.5 hours of operation	ND for all compounds – flat chromatogram.
C23 BED 1 14:00 Adsorption time = 120 Minutes	Adsorption bed 1 effluent after 2 hours of operation	ND for all compounds – flat chromatogram.

Figure 9. Desorption Effluent TCE Concentration versus Time

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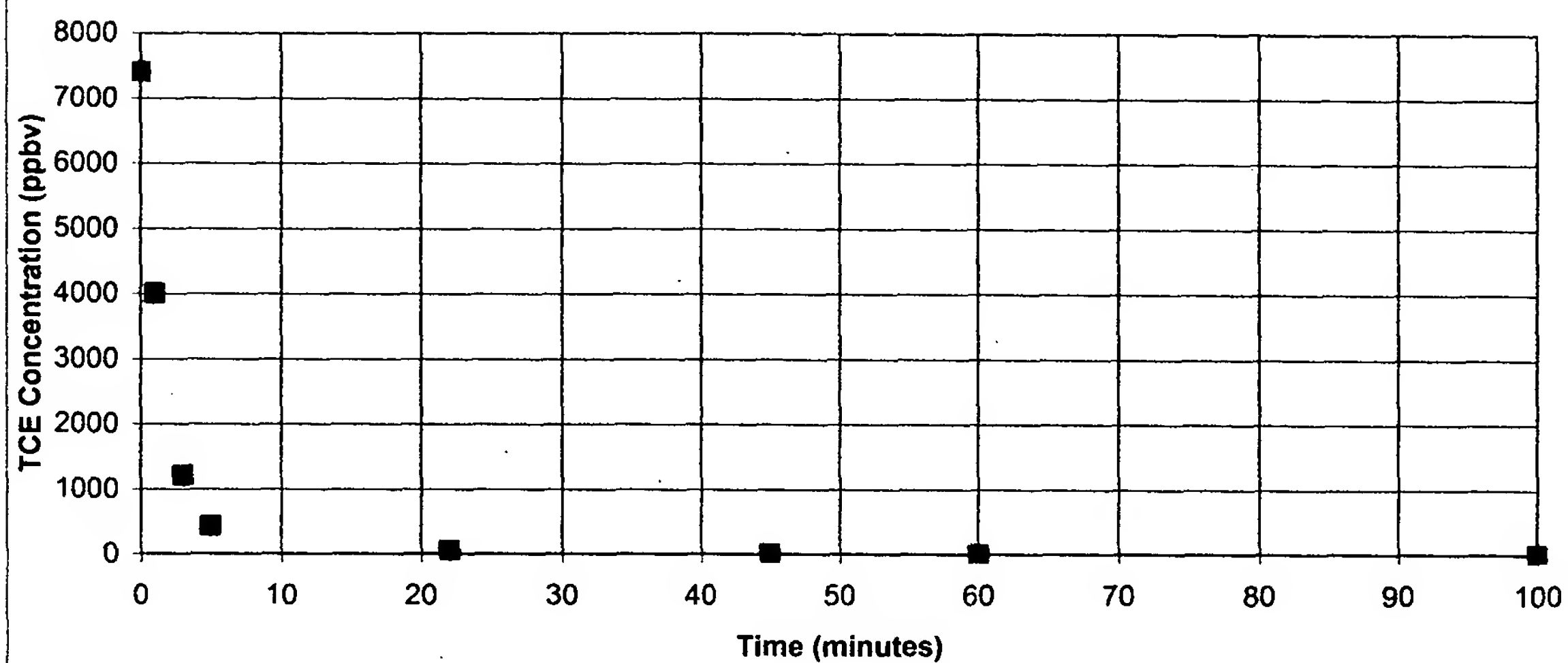
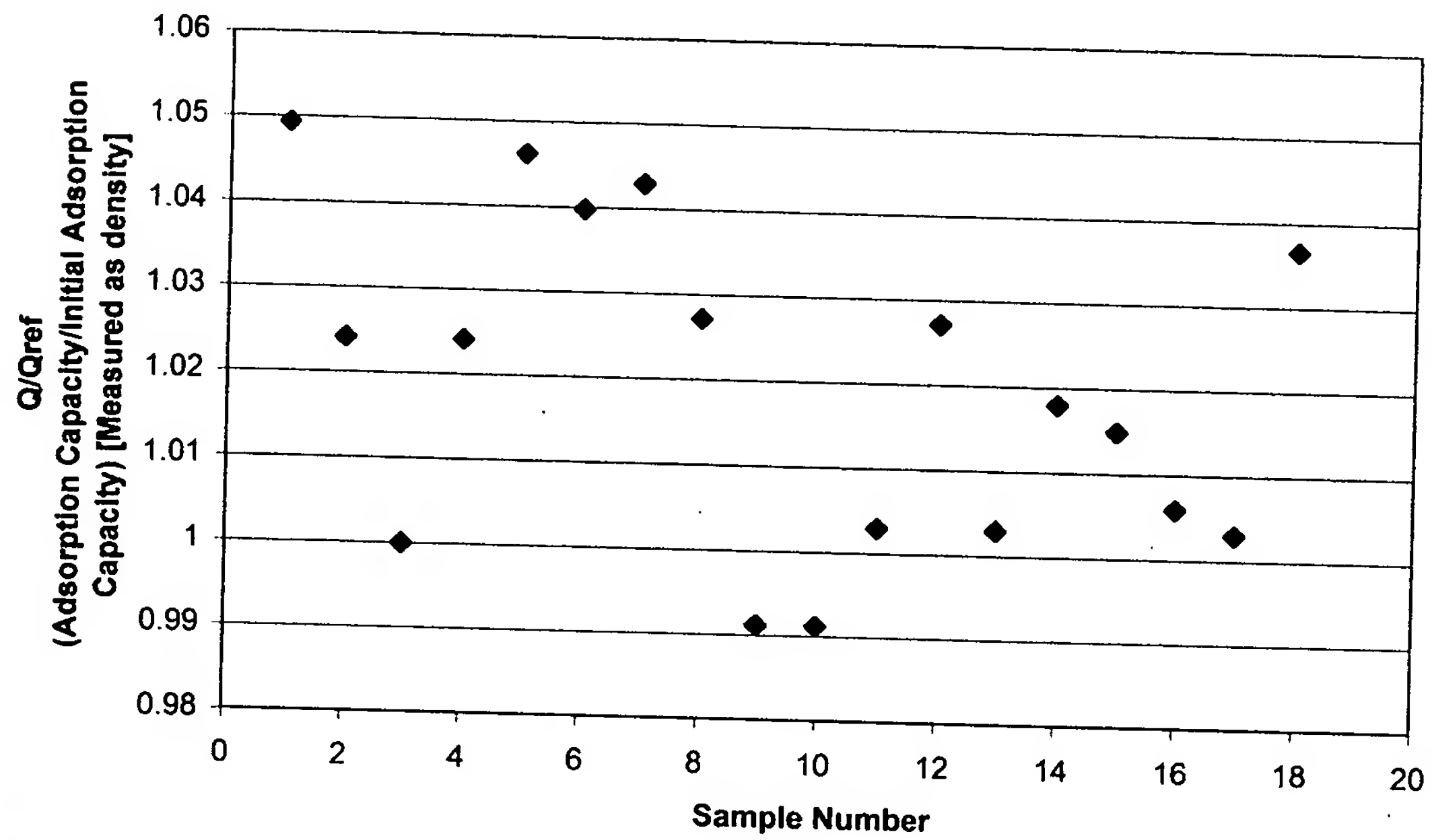


Figure 10. Resin Adsorption Capacity v r Multiple Cycl s

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**Figure 11. Unspecified Polymeric Resin Performance for Repeated
Regeneration Cycles (from Y. Cohen, 1998)**

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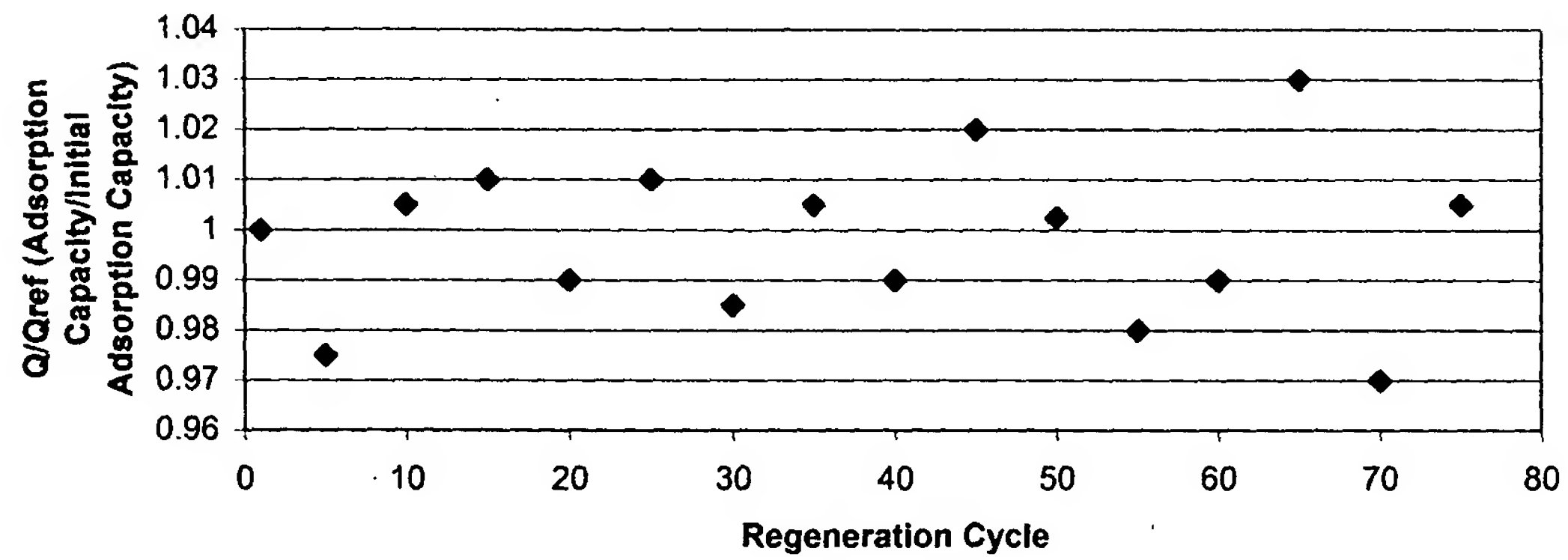


Figure 12. Generalized System Components

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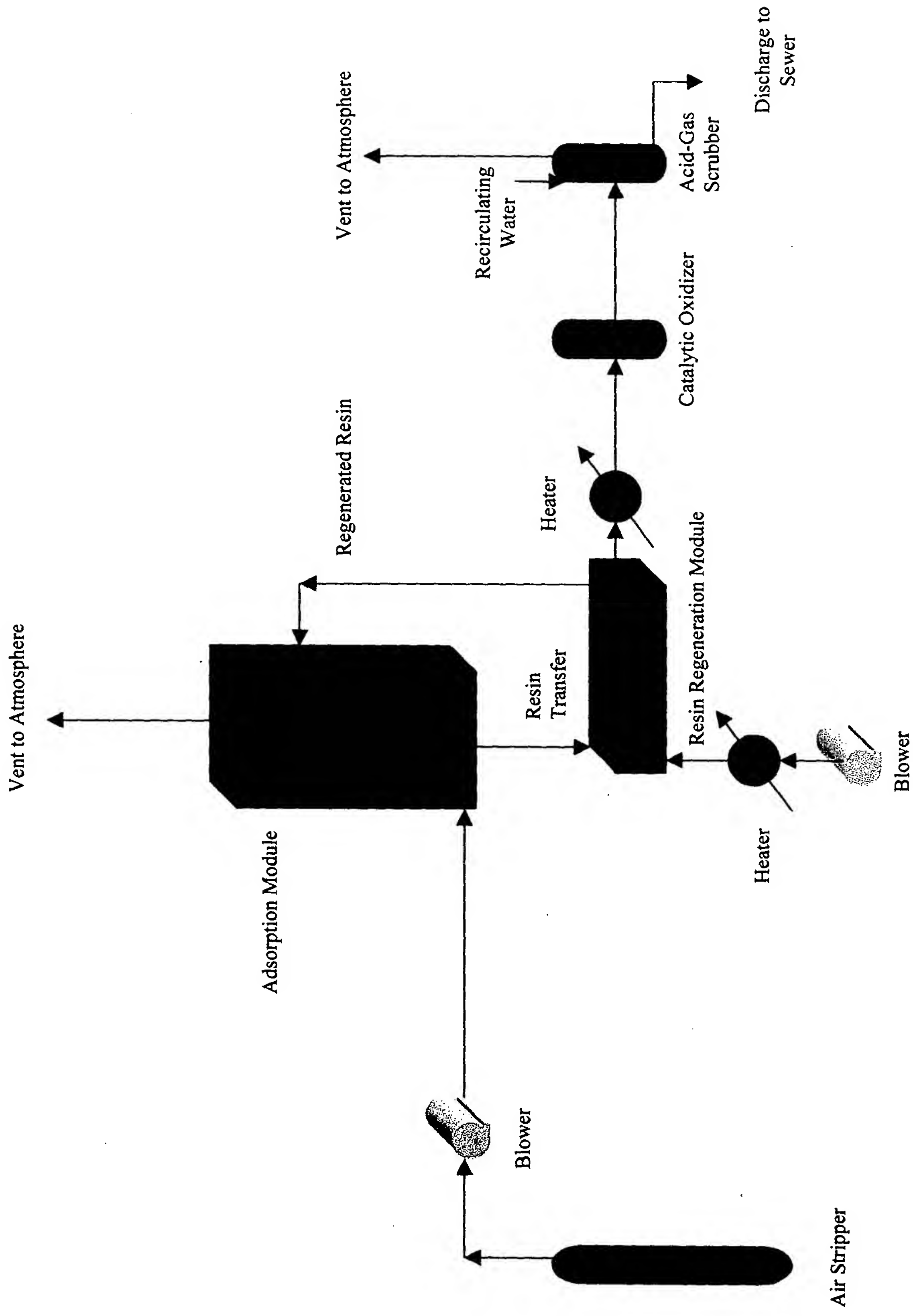
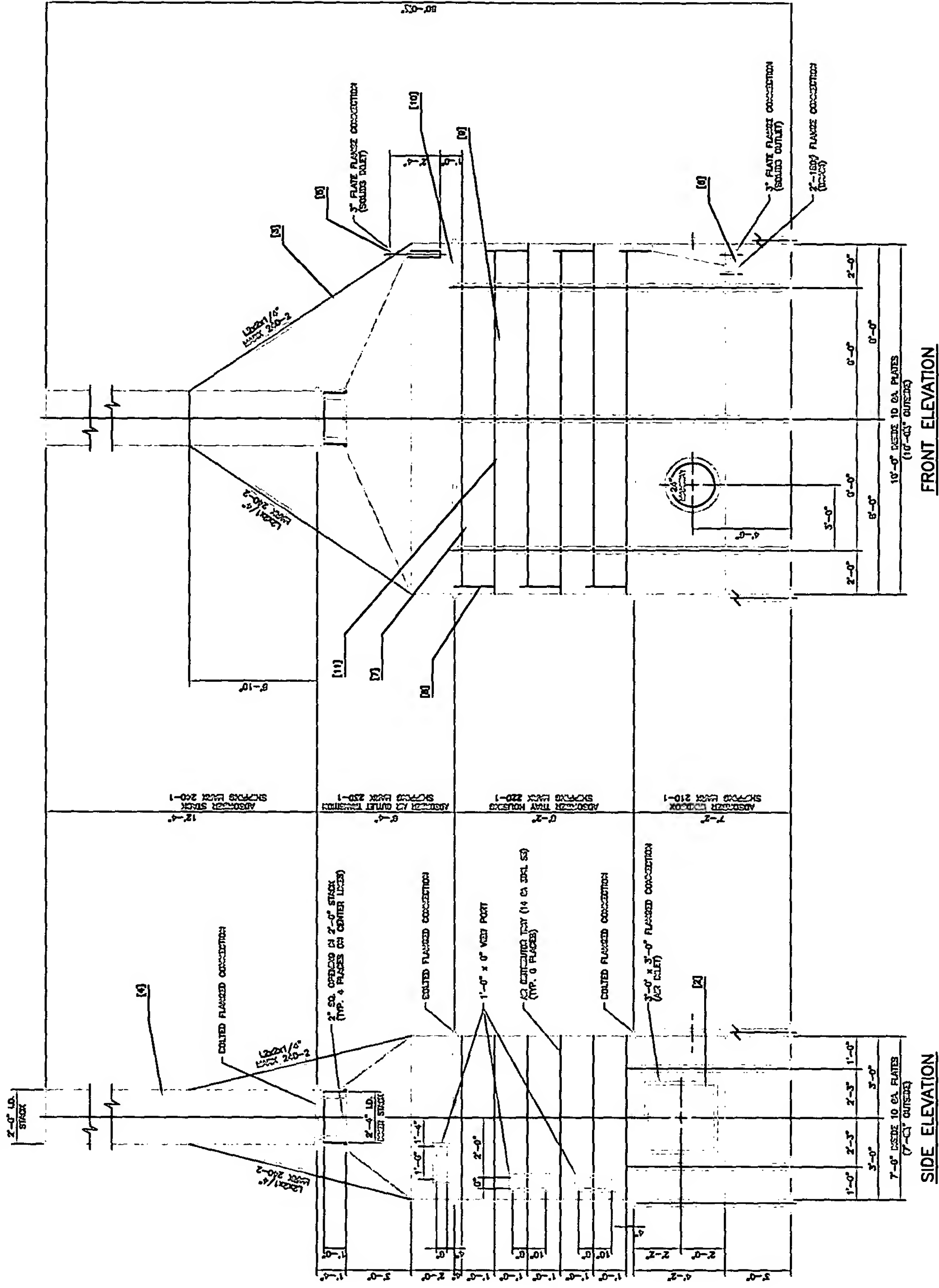
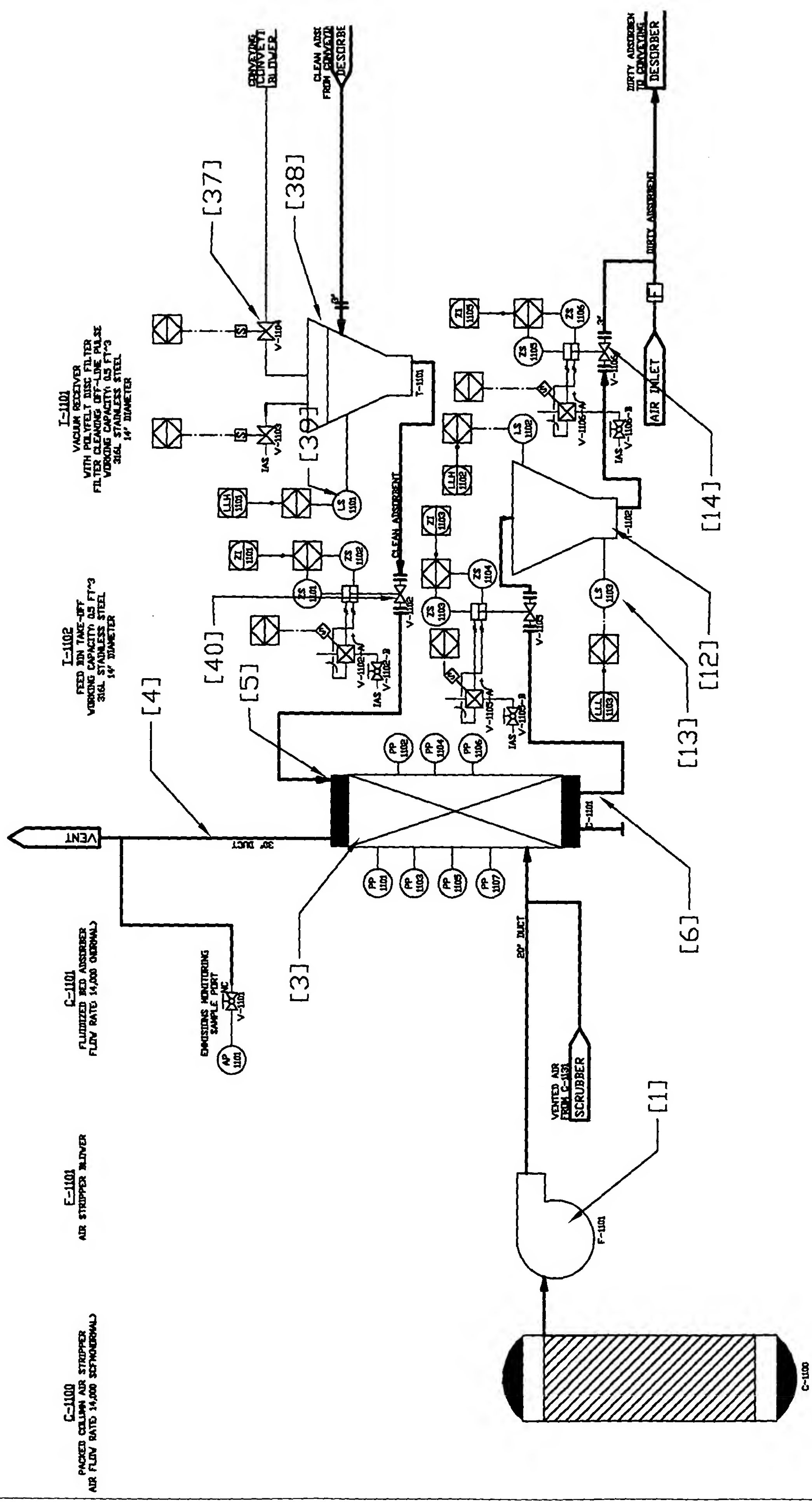


FIGURE 13. PREFERRED EMBODIMENT GENERALIZED LAYOUT AND P&ID
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 METHOD FOR ACHIEVING ULTRA-LOW EMISSION LIMITS FOR
 VOC/HAP/TAC CONTROL



P&ID (CONTINUED) MATTHEW L. MCCULLOUGH METHOD FOR ACHIEVING ULTRALOW EMISSION LIMITS FOR VOC/HAP/TAC CONTROL



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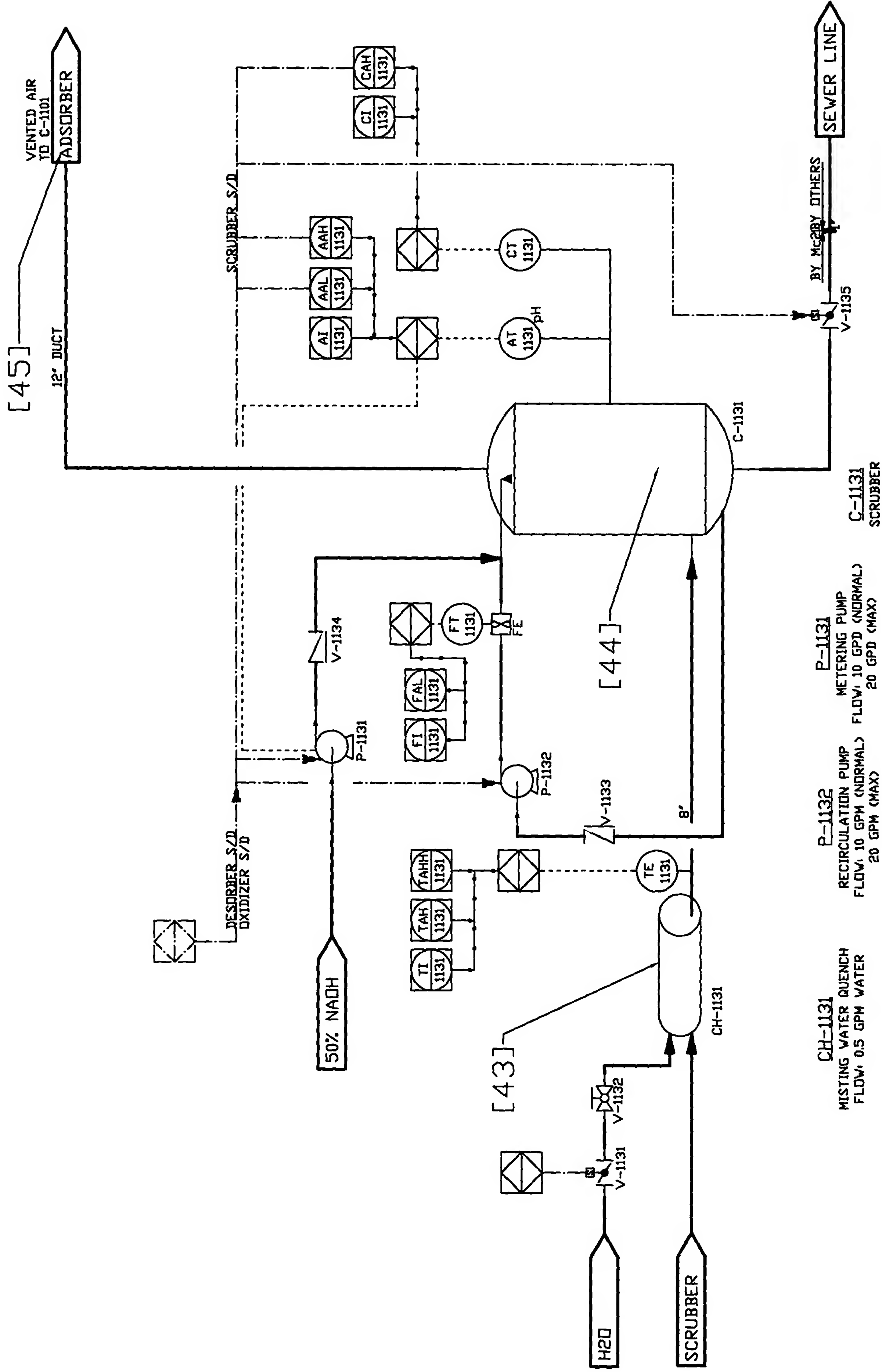


FIGURE 17. PREFERRED EMBODIMENT GENERALIZED LAYOUT AND P&ID (CONTINUED)
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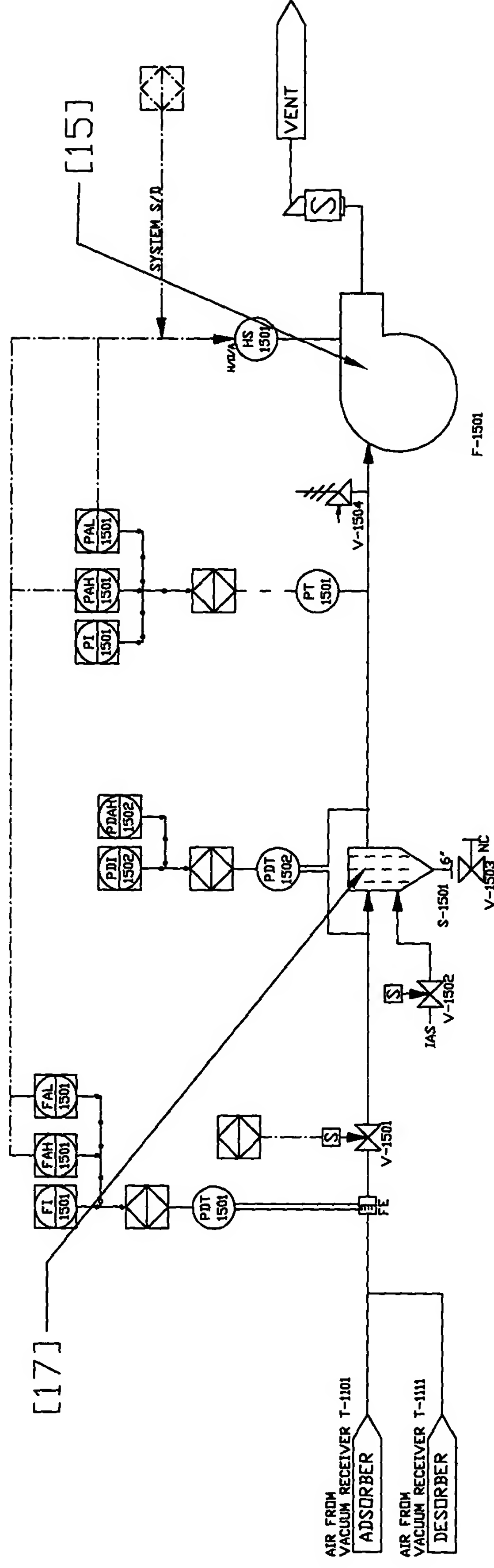


FIGURE 18. PREFERRED EMBODIEMENT GENERALIZED LAYOUT AND P&ID (CONTINUED)

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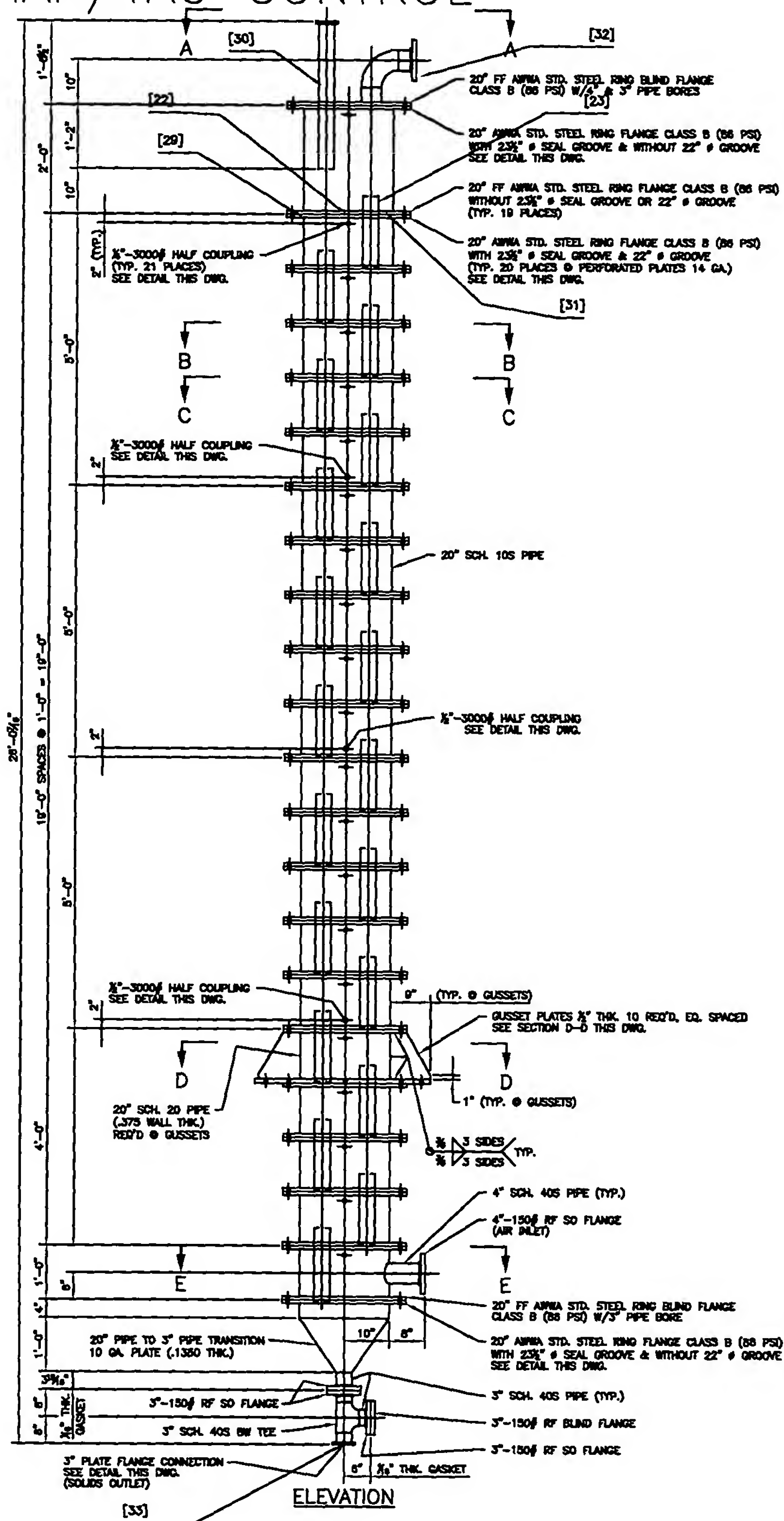


Figure 19. Alternative Embodiment for Recovery of Low Boiling Point Compounds

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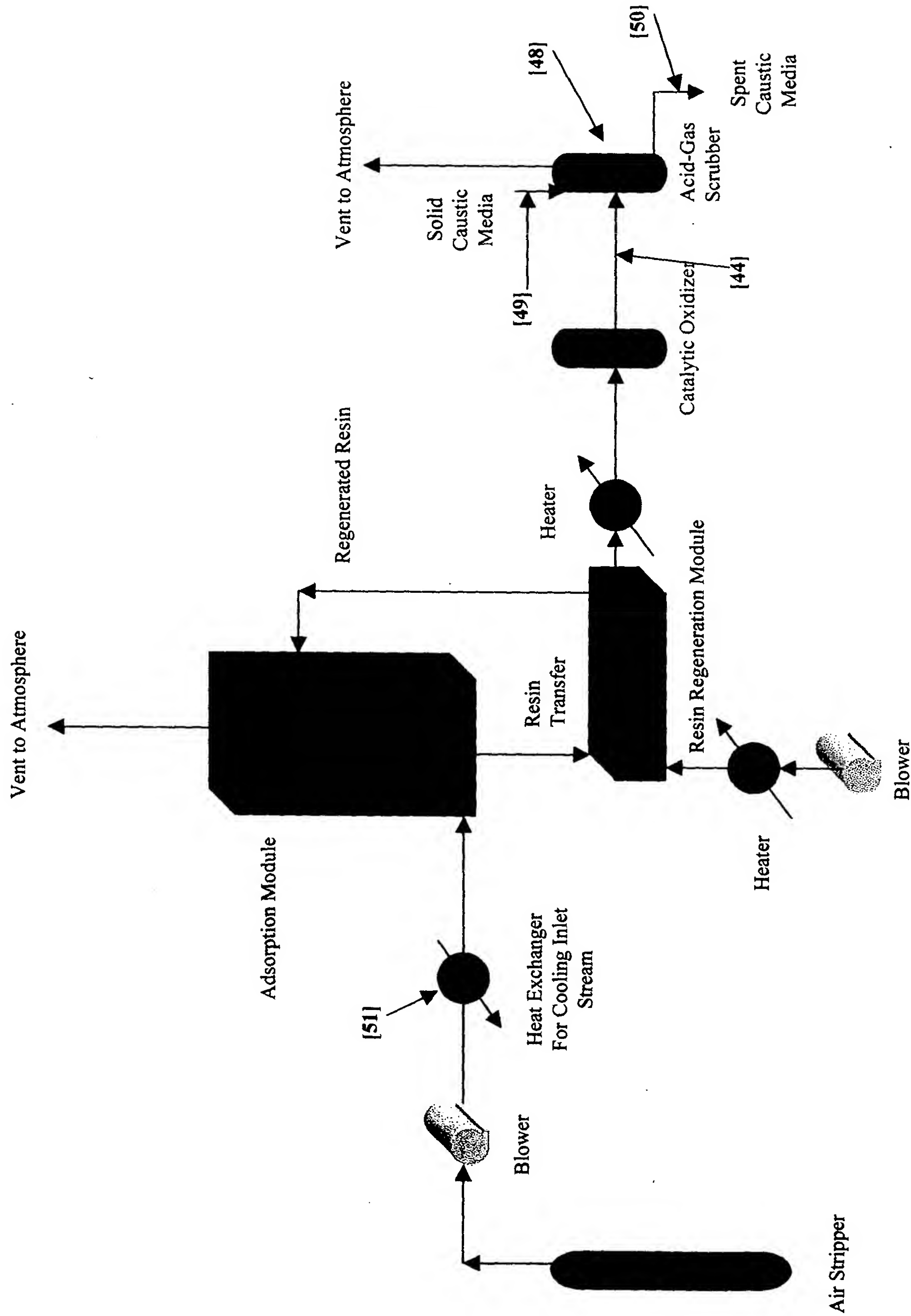


Figure 20. Alternative Embodiment Utilizing Recirculating Fluidized Bed

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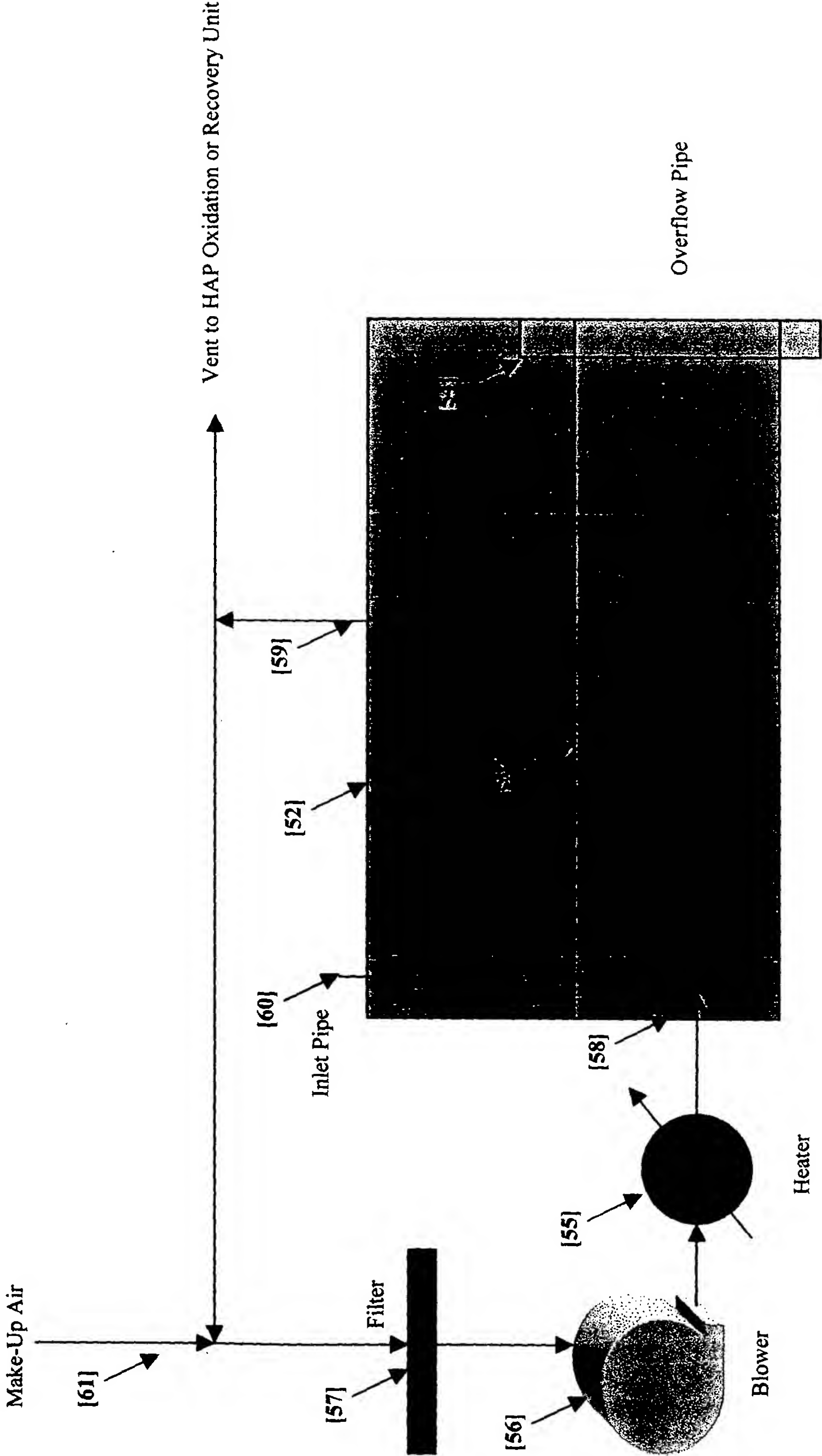


Figure 21. Alternative Embodiment for Recovery of Liquid Solvent

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